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Pankaj Gargotra
(1) ICAR-Directorate of Coldwater Fisheries Research Bhimtal, Uttarakhand, India
(2) Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, Kerala, India

Dinesh Kaippily
Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, Kerala, India

Chiranjiv Pradhan
Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, Kerala, India

Parvaiz Ahmad Ganie
ICAR-Directorate of Coldwater Fisheries Research Bhimtal, Uttarakhand, India

Alphi Korath
Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, Kerala, India

Corresponding Author:
Pankaj Gargotra
(1) ICAR-Directorate of Coldwater Fisheries Research Bhimtal, Uttarakhand, India
(2) Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, Kerala, India

Dietary potential of guar meal to replace soy meal on the survival and growth of *Cyprinus carpio* (Linnaeus, 1748) spawn

Pankaj Gargotra, Dinesh Kaippily, Chiranjiv Pradhan, Parvaiz Ahmad Ganie and Alphi Korath

Abstract
Carps account for roughly 90% of production in inland aquaculture and constitute the backbone of Indian fisheries. The development of feeding technology is crucial for the expansion of a target species' aquaculture activities. Larval nutrition has gained more attention in the last few years. It is clearly evident that common carp larvae show a great tendency towards zooplankton but will also readily ingest floating supplementary or balanced feeds if the particle size is small enough to swallow one of the causes of larval mortality is a lack of the proper kind and amount of live food. It has already been proven that plant-based components can substitute fish meal in the diet. Native to the Indian subcontinent, guar is an annual herb that may grow up to 2 meters tall. It is mostly grown for its endosperm, which contains galactomannans, and for its by-product, which is a valuable component of animal feed. The purpose of the current study is to evaluate the effectiveness of guar meal as a suitable feed ingredient, to determine the commercial viability of such a substitution, and to provide some preliminary observations about guar meal's suitability for the aquaculture business. The experiment utilized a completely randomized design (CRD) with five treatments (0%, 10%, 20%, 30%, and 40% guar replacement) (including one control). Treatment means were compared with the post hoc test and Duncan‘s multiple range test. All the growth parameters recorded show an increasing trend up to 30% replacement, which indicates that the effective replacement of soy meal by guar meal up to 30% does not have any significant effect on the growth and survival of common carp larvae. Thus, we recommend that soy meal can be effectively replaced by guar meal up to the level of 30%.

Keywords: Soy meal, guar, carp, growth, FCR, FCE

1. Introduction
Carps are the mainstay of Indian fisheries production contributing about 90% of inland aquaculture production. Of these, common carp is widely distributed and cultured in different forms of aquaculture production. The expansion of aquaculture practices of a target species greatly depends on feeding technology (De Silva and Davy, 1992) [6]. Feed generally accounts for 50-80% of the total production cost and determines its total profit or loss. Due to the high costs of fish meal and the dramatic decrease in fish catch, the demand for alternative protein sources is increasing day by day (Hardy, 2000; Kraugerud and Svihus, 2011) [8, 12].

For the last few years, attempts have been made to promote the use of plant ingredients and to replace them either partially or fully with conventional feed ingredients like fish meal and soy meal. Due to the increasing demand of fish meal due to reduced supply coupled with high cost, the demand for plant ingredients is increasing day by day. There is a great future for agriculture by-products to be used as potential feed ingredients in aquaculture. The price and availability of an ingredient have to be taken under consideration while selecting it as a feed ingredient. Guar has been used in the present research work as a potential ingredient for rearing carp spawn. One of the major reasons to use it in the present study was its easy availability and lower price compared to fish meal and soy meal. Moreover, India is the leading producer of guar and produces about 21 lakh tones annually (2017-2018). Rajasthan and Gujarat are the leading producers of guar in India.

Dietary replacement of fish meal with plant-based ingredients has already been demonstrated and their results have shown that replacement up to 40% inclusion level will not affect the growth and survival of cultured species (De Silva, 2006) [7]. At present, soybean meal (SBM) is the most important alternative protein ingredient that had grabbed a great interest in the aquaculture industry.

Recently, it has been shown by several studies that high concentrations of carbohydrates, the presence of anti-nutritional factors (ANF) and high cost are believed to be the primary factors limiting its use in feed formulation (Joshi *et al*., 2020) [10]

Guar (*Cyamopsis tetragonoloba*), commonly known as cluster bean, is an annual herb with rose-coloured blossoms that can reach a height of 2 metres. It is indigenous to the Indian subcontinent and is mostly grown for industrial purposes because of the galactomannans in its endosperm, as well as for a valuable by-product used in animal feed (Saeed *et al*., 2017; Biel and Jaroszewska, 2019) [22, 2]. Guar meal has demonstrated encouraging performance in animal feeding, particularly for poultry and cattle. Guar is virtually as high-quality as soy meal, costs much less than soy, and is more readily available, especially in drought-prone areas (Mudgil *et al*., 2014) [18].

Larval nutrition has gained more attention in the last few years. Larvae being small in size, do not accept feed particles greater than 50-70 µm in size. It is clearly evident that common carp larvae show a great tendency towards zooplankton but will also readily ingest floating supplementary or balanced feeds if the particle size is small enough to swallow (Dabrowski and Bardega, 1984) [5]. The lack or shortage of the right type and size of live food is one of the reasons for larval mortality. Due to the non-availability of a proper larval diet, the survival rate in larval rearing is generally very low (Singh *et al*., 2014) [24]. To rectify the problem of the non-availability of live feeds, several attempts have been made in the past to develop artificial diets to replace live food. Mohapatra and Patra (2014) [17] have documented successful trials of artificial feed made of fish meal and soybean on common carp, similarly, Solomon *et al*. (2015) [25] opined that the egg-based diet can enhance the growth performance of common carp fry. Singh *et al*. (2018) [23] also reported that soybean meal and fish silage-based artificial feed could enhance the growth and survival of common carp fingerlings. Further, Potki *et al*. (2018) [20] stated that feeding the common carp with diets containing corn gluten meal can enhance its growth, haematological and biochemical indices. While evaluating the impact of plant oil-based diets complemented with β-glucan Nguyen *et al*. (2019) [19] reported an enhancement in the growth performance and immune status in common carp. Replacement of fish meal with plant-based meals through proper feed formulation is known to be a better option for sustainable and cost-effective aquaculture (Carter and Hauler, 2000 and Hodar *et al*., 2020) [3, 9].

The purpose of the current study is to evaluate the effectiveness of guar meal as a suitable feed element, determine the commercial viability of such a substitution, and make preliminary observations about guar meal's suitability for the aquaculture sector.

2. Material and Methods

2.1 Experimental fish and rearing conditions

2.1.1 Experimental animals

1-day-old common carp spawns were bought from National Fish Seed Farm, Malampuzha, Kerala. The biometric data on total length and body weight were recorded prior to their stocking. The average weight recorded before stocking was 0.038gm. The larvae were packed in 2 oxygen-filled polythene bags and transported from Malampuzha to the wet laboratory. Care was taken to avoid any sort of stress to spawn.

2.1.2 Experimental tanks

20 rectangular tanks made of inert material with 20 l capacity each were used for the study. The height of the tanks used was 60 cm. Each tank was provided with a 4-inch sponge filter covered with a muslin cloth. Rearing water was replaced at the rate of 10% on daily basis. 50 numbers larvae were added to each tank filled with 15l of treated water.

2.1.3 Weaning

During the first two days, larvae were fed microalgae. After the second day, larvae were provided with 75% microalgae and 25% artificial feed for the next two days. From the 4th day onwards, larvae were given 50% microalgae and 50% experimental feed till 7th day, which was changed to 100% experimental diets, from the 7th day onwards.

2.2 Experimental diets and feeding trials

2.2.1 Feeding trials

Five iso-nitrogenous (30% CP) and iso-caloric feeds (5% lipid) were prepared with graded replacement of soya-meal with guar meal (table 1). GOC, maize, tapioca, soymeal, guar, vitamin-mineral mixture, and vegetable oil were used in the feed preparation. The feed was prepared by grinding all the ingredients and filtering through a sieve. All the ingredients were first mixed together except the vitamin-mineral mixture and oil. After mixing all the ingredients vitamin and mineral mixture were added along with oil. As larvae have very small mouth openings, finely powdered feed (with a particle size of 50-200 microns initially and 300-700 microns later) was fed to them four times a day. Siphoning was done on a daily basis to remove fish wastes and leftover feed particles. Siphoning was done after stopping the aeration for 10 minutes. Care was taken to avoid stress to the animals.

2.3 Growth parameters

The efficacy of diets was examined using different growth parameters as described by Baba *et al*. (2016) [1]. The parameters examined were average weight gain, average length gain, specific growth rate (SGR), feed conversion ratio (FCR), feed conversion efficiency (FCE), average daily growth rate (% ADG), percentage increment in growth, survival rate, and normalized biomass index (NBI).

2.3.1 Percentage increment in growth

Net weight gain (mg) = Net final weight (mg) – Net initial weight (mg).

Average length gain (mm) = average final length (mm) – average initial length (mm).

2.3.1 Specific growth rate (SGR)

Specific growth rate gives the average increase in weight per day and it is calculated by the following equation.

$$\text{SGR} = \frac{\text{loge final body weight} - \text{loge initial body weight}}{\text{Time period of the experiment}} \times 100$$

2.3.2 Feed conversion ratio (FCR)

The ability of an organism to convert feed into body mass is known as feed conversion ratio and is the most commonly used index to find out the efficiency of any feed. FCR is calculated by the following equation

FCR = total feed intake (g) ÷ total weight gain (g).

2.3.3 Feed conversion efficiency (FCE)

FCE is the reciprocal of FCR and can be calculated by the following equation

$$FCE = \frac{\text{Gain in weight (mg)}}{\text{Feed intake (mg)}} \times 100$$

2.3.4 Average daily growth rate (% ADG)

$$ADG\% = \frac{\text{final body weight} - \text{initial body weight}}{\text{Initial weight} \times \text{time period of experiment}} \times 100$$

2.3.5 Survival rate %

Survival rate of larvae is calculated by following equation.

$$(\text{Final number of larvae} - \text{initial number of larvae}) \times 100$$

2.3.6 Normalized biomass index (NBI)

NBI was calculated as per the formula given by Beck (1979) [29], to get the combined effect of growth and survival.

$$NBI = \frac{[(Wf \times Nf) - (Wi \times Ni)]}{100},$$

Where, Wf = final average weight
Nf = final number,
Ni = initial number,
WI = initial average weight

2.4 Statistical analysis

The means and standard deviations of the data (SD, n = 3) were displayed. One-way analysis of variance (ANOVA) was employed for the comparison of the mean values following the normality and heterogeneity of variance tests (SPSS19.0, SPSS Inc., Chicago, USA). Post hoc test and Duncan‘s multiple-range tests were performed on the data for comparison of means. Statistically significant differences were described as $p<0.05$.

3. Results

Dietary replacement of guar shows a positive impact on the growth parameters of carp spawn and from the results explained below it is clear evidence that the inclusion of guar up to 30% has a direct and positive relationship among the recorded parameters. Statistical analysis also showed that the inclusion of guar at a level of 30% in the feed of carp spawn shows the maximum yield.

3.1 Growth performance in terms of weight and length increase

The final weight gain was in the range of 488-897 mg. The maximum weight gain was reported from treatment 3 while the lowest was from control. The weight increment recorded in the present study is presented in table 2.

The average length gained by larvae after 30 days is presented in table 3. The result shows that the maximum length gain was from treatment 3 while the lowest was from control.

3.2 Survival rate (%)

The survival rate of larvae fed with different diets was in the range of 68-82%. The highest survival rate was obtained in treatment 3. The lowest survival rate was from the control. The average % survival rate of larvae fed with different diets is presented in table 4.

3.3 Specific growth rate (SGR)

The highest survival rate of larvae fed with different diets is reported from treatment 3. The average SGR of the culture tanks was in the range of 2.5-3.5%. The mean SGR of larvae under different treatments is given in table 2.

3.4 Normalized biomass index (NBI)

NBI of the larvae under different treatments was in the range of 2.8-6.7. The maximum NBI was reported from treatment 3 and the lowest was from the control. The NBI, combined effect of growth and survival is presented in table 6.

3.5 Food conversion ratio (FCR) and Feed conversion efficiency (FCE)

FCR and FCE of larvae under different treatments are presented in table 7. The recorded value of FCR and FCE under different treatments varied from 0.66-1.43 and 0.7- 1.5 respectively.

3.6 Average daily growth rate

The average daily growth rate of larvae under different treatment conditions is in the range of 7.5-17.7%. The highest ADG was reported from treatment 3 while the lowest was from control. The average daily growth performance of larvae is presented in table 8.

Table 1: Proximate composition of experimental diets

Ingredients	Feed 1 (0% Guar)	Feed 2 (10% Guar)	Feed 3 (20% Guar)	Feed 4 (30% Guar)	Feed 5 (40% Guar)
Guar meal	0	10	20	30	40
Soybean	40	35	30	25	20
GOC	20	20	20	20	20
Maize	25	20	15	15	10
Tapioca	10	10	10	5	5
Veg oil	1	1	1	1	1
Vit + mineral	4	4	4	4	4

Table 2: Weight gain from treatments under different guar concentrations

Treatments	Initial weight (mg)	Final weight (mg)	Percent (%) weight gain
C1	190.0	488.4	157.1
C2	190.0	489.6	157.7
C3	190.0	565.2	197.5
C4	190.0	525.0	176.3
Mean ± S.D	190.0±0	517.1±36.3	172.1±19.1[e]
T1R1	190.0	643.8	238.8
T1R2	190.0	763.2	301.7
T1R3	190.0	758.5	299.2
T1R4	190.0	684.5	260.3
Mean ± S.D	190.0±0	712.5±58.3	275.0±30.7[c]
T2R1	190.0	792.0	316.8
T2R2	190.0	795.6	318.7
T2R3	190.0	786.6	314.0
T2R4	190.0	820.8	332.0
Mean ± S.D	190.0±0	798.8±15.2	320.4±8.0[b]
T3R1	190.0	892.0	369.5
T3R2	190.0	865.2	355.4
T3R3	190.0	888.0	367.4
T3R4	190.0	897.9	372.6
Mean ± S.D	190.0±0	885.8±14.3	366.2±7.5[a]
T4R1	190.0	691.6	264.0
T4R2	190.0	647.5	240.8
T4R3	190.0	657.4	246.0
T4R4	190.0	702.0	269.5
Mean ± S.D	190.0±0	674.6±26.3	255.1±13.8[d]

Table 3: Length gain from treatments under different guar concentrations

Treatments	Initial length (cm)	Final length (cm)
C1	0.20	0.80
C2	0.20	0.70
C3	0.20	0.73
C4	0.20	0.67
Mean ± S.D	0.20±0	0.73±0.006[e]
T1R1	0.20	1.13
T1R2	0.20	0.94
T1R3	0.20	1.10
T1R4	0.20	0.97
Mean ± S.D	0.20±0	1.04±0.009[d]
T2R1	0.20	1.54
T2R2	0.20	1.97
T2R3	0.20	2.00
T2R4	0.20	2.03
Mean ± S.D	0.20±0	1.89±0.23[c]
T3R1	0.20	1.90
T3R2	0.20	1.87
T3R3	0.20	1.97
T3R4	0.20	1.97
Mean ± S.D	0.20±0	1.93±0.005[a]
T4R1	0.20	1.94
T4R2	0.20	1.87
T4R3	0.20	1.90
T4R4	0.20	1.87
Mean ± S.D	0.20±0	1.90±0.003[b]

Table 4: Survival rate recorded from treatments under different guar concentrations

Treatments	Stocking number	Mortality recorded	Survival number	Survival %
C1	50		37.0	74.0
C2	50		34.0	68.0
C3	50		36.0	72.0
C4	50		35.0	70.0
Mean ± S.D	50		35.5±1.3	71.0±2.6[e]
T1R1	50		37.0	74.0
T1R2	50		36.0	72.0
T1R3	50		37.0	74.0
T1R4	50		37.0	74.0
Mean ± S.D	50		36.8±0.5	73.5±1.0[d]
T2R1	50		36.0	72.0
T2R2	50		39.0	78.0
T2R3	50		38.0	76.0
T2R4	50		38.0	76.0
Mean ± S.D	50		37.8±1.3	75.5±2.5[b]
T3R1	50		40.0	80.0
T3R2	50		42.0	84.0
T3R3	50		40.0	80.0
T3R4	50		41.0	82.0
Mean ± S.D	50		40.8±1.0	81.5±1.9[a]
T4R1	50		38.0	76.0
T4R2	50		37.0	74.0
T4R3	50		38.0	76.0
T4R4	50		36.0	72.0
Mean ± S.D	50		37.3±1.0	74.5±1.9[c]

Table 5: SGR recorded from treatments under different guar concentrations

Treatments	Avg. initial weight	Avg. final weight	SGR
C1	190.0	488.4	2.575192
C2	190.0	489.6	2.755138
C3	190.0	565.2	2.933886
C4	190.0	525.0	2.83956
Mean ± S.D	190.0±0	517.1±36.3	2.77±0.15[e]
T1R1	190.0	643.8	3.146503
T1R2	190.0	763.2	3.555011
T1R3	190.0	758.5	3.485573
T1R4	190.0	684.5	3.273277
Mean ± S.D	190.0±0	712.5±58.3	3.36±0.18[c]
T2R1	190.0	792.0	3.631615
T2R2	190.0	795.6	3.47546
T2R3	190.0	786.6	3.505651
T2R4	190.0	820.8	3.593667
Mean ± S.D	190.0±0	798.8±15.2	3.55±0.07[b]
T3R1	190.0	892.0	3.659625
T3R2	190.0	865.2	3.495636
T3R3	190.0	888.0	3.65033
T3R4	190.0	897.9	3.622193
Mean ± S.D	190.0±0	885.8±14.3	3.60±0.07[a]
T4R1	190.0	691.6	3.239466
T4R2	190.0	647.5	3.158355
T4R3	190.0	657.4	3.134583
T4R4	190.0	702.0	3.382148
Mean ± S.D	190.0±0	674.6±26.3	3.22±0.11[d]

Table 6: NBI recorded from treatments under different guar concentrations

Treatments	Average initial weight	Average final weight	Initial number	Final number	NBI
C1	190.0	488.4	50.0	37.0	3.0
C2	190.0	489.6	50.0	34.0	3.0
C3	190.0	565.2	50.0	36.0	3.8
C4	190.0	525.0	50.0	35.0	3.4
Mean ± S.D	190.0±0	517.1±36.3	50.0±0	35.5±1.3	3.3±0.4[e]
T1R1	190.0	643.8	50.0	37.0	4.5
T1R2	190.0	763.2	50.0	36.0	5.7
T1R3	190.0	758.5	50.0	37.0	5.7
T1R4	190.0	684.5	50.0	37.0	4.9
Mean ± S.D	190.0 ± 0	712.5 ± 58.3	50.0 ± 0	36.8 ± 0.5	5.2 ± 0.6[c]
T2R1	190.0	792.0	50.0	36.0	6.0
T2R2	190.0	795.6	50.0	39.0	6.1
T2R3	190.0	786.6	50.0	38.0	6.0
T2R4	190.0	820.8	50.0	38.0	6.3
Mean ± S.D	190.0±0	798.8±15.2	50.0±0	37.8±1.3	6.1±0.2[b]
T3R1	190.0	892.0	50.0	40.0	7.0
T3R2	190.0	865.2	50.0	42.0	6.8
T3R3	190.0	888.0	50.0	40.0	7.0
T3R4	190.0	897.9	50.0	41.0	7.1
Mean ± S.D	190.0±0	885.8±14.3	50.0±0	40.8±1.0	7.0±0.1[a]
T4R1	190.0	691.6	50.0	38.0	5.0
T4R2	190.0	647.5	50.0	37.0	4.6
T4R3	190.0	657.4	50.0	38.0	4.7
T4R4	190.0	702.0	50.0	36.0	5.1
Mean ± S.D	190.0±0	674.6±26.3	50.0±0	37.3±1.0	4.8±0.3[d]

Table 7: FCR and FCE recorded from treatments under different guar concentrations

Treatments	Average initial weight	Average final weight	Weight gain	Average feed intake	FCR	FCE
C1	190	488.40	298.40	462.00	1.55	0.65
C2	190	489.60	299.60	462.00	1.54	0.65
C3	190	565.20	375.20	462.00	1.23	0.65
C4	190	525.00	335.00	462.00	1.38	0.81
Mean ± S.D	190.0±0	517.05±36.31	327.05±36.31	462.00±0	1.43±0.15[e]	0.73±0.71[e]
T1R1	190	643.80	453.80	462.00	1.02	0.98
T1R2	190	763.20	573.20	462.00	0.81	1.24
T1R3	190	758.50	568.50	462.00	0.81	1.23
T1R4	190	684.50	494.50	462.00	0.93	1.07
Mean ± S.D	190.0±0	712.50±58.28	522.5±58.28	462.00±0	0.89±0.1[c]	1.13±0.13[c]
T2R1	190	792.00	602.00	462.00	0.77	1.30
T2R2	190	795.60	605.60	462.00	0.76	1.31
T2R3	190	786.60	596.60	462.00	0.77	1.29
T2R4	190	820.80	630.80	462.00	0.73	1.37
Mean ± S.D	190.0±0	798.75±15.16	608.75±15.16	462.00±0	0.76±0.02[b]	1.32±0.03[b]
T3R1	190	892.00	702.00	462.00	0.66	1.52
T3R2	190	865.20	675.20	462.00	0.68	1.52
T3R3	190	888.00	698.00	462.00	0.66	1.46
T3R4	190	897.90	707.90	462.00	0.65	1.51
Mean ± S.D	190.0±0	885.78±14.31	695.78±14.31	462.00±0	0.66±0.01[a]	1.53±0.51[a]
T4R1	190	691.60	501.60	462.00	0.92	1.09
T4R2	190	647.50	457.50	462.00	1.01	0.99
T4R3	190	657.40	467.40	462.00	0.99	1.01
T4R4	190	702.00	512.00	462.00	0.90	1.11
Mean ± S.D	190.0±0	674.63±26.27	484.63±26.27	462.00±0	0.96±0.05[d]	1.05±0.06[d]

Table 8: ADG recorded from treatments under different guar concentrations

Treatments	Initial no	Final no	Average Initial weight	Average Final weight	ADG %
C1	50.0	37.0	190.0	488.4	7.5
C2	50.0	34.0	190.0	489.6	7.5
C3	50.0	36.0	190.0	565.2	9.4
C4	50.0	35.0	190.0	525.0	8.4
Mean ± S.D	50.0±0	35.5±.3	190.0±0	517.1±36.3	8.2±0.9[e]
T1R1	50.0	37.0	190.0	643.8	11.4
T1R2	50.0	36.0	190.0	763.2	14.4
T1R3	50.0	37.0	190.0	758.5	14.2
T1R4	50.0	37.0	190.0	684.5	12.4
Mean ± S.D	50.0±0	36.8±0.5	190.0±0	712.5±58.3	13.1±1.5[c]
T2R1	50.0	36.0	190.0	792.0	15.1
T2R2	50.0	39.0	190.0	795.6	15.2
T2R3	50.0	38.0	190.0	786.6	15.0
T2R4	50.0	38.0	190.0	820.8	15.8
Mean ± S.D	50.0±0	37.8±1.3	190.0±0	798.8±15.2	15.3±0.4[b]
T3R1	50.0	40.0	190.0	892.0	17.6
T3R2	50.0	42.0	190.0	865.2	16.9
T3R3	50.0	40.0	190.0	888.0	17.5
T3R4	50.0	41.0	190.0	897.9	17.7
Mean ± S.D	50.0±0	40.8±1.0	190.0±0	885.8±14.3	17.4±0.4[a]
T4R1	50.0	38.0	190.0	691.6	12.6
T4R2	50.0	37.0	190.0	647.5	11.5
T4R3	50.0	38.0	190.0	657.4	11.7
T4R4	50.0	36.0	190.0	702.0	12.8
Mean ± S.D	50.0±0	37.3±1.0	190.0±0	674.6±26.3	12.1±0.7[d]

4. Discussion

Growth and survival represent the most important parameters when determining the utilization of any feed ingredient. Many studies have been done on the replacement of fish meal by other non-conventional ingredients. Soy meal, rice bran, wheat flour and GOC have been investigated on a large scale in replacement of fish meal (add refencs where replacement has been done)

After the trial period of 30 days, the net weight gain reported was in the range of 488-897mg. A linear relationship between the percentage of protein content in the diet and the increase in weight gain up to an incorporation rate of 40% was noted by Ahmed and Maqbool (2016) [30]. Carvalho *et al*. (1997) [4] reported 82.8 mg wet weight gain while feeding with casein-based diet and 55.4 mg wet weight gain by feeding with yeast-based diet. Similarly, Zaki *et al*. (1994) [28] documented the final weight of common carp in the range of 2.22-3.04 gm, after feeding them with seaweeds for a period of 98 days. Mohapatra and Patra (2014) [17] also reported the fish fry size in the range of 6.21g-8.4g (120 days old) similar results in weight gain were also reported in the present study, with the dietary inclusion of Guar up to 30%.

Mazurkiewicz *et al*. (2017) [16] recorded the survival rate of common carp in the range of 85.3% to 96%. According to the reports of FAO, common carp larvae have a survivability of 40-70% during the first three weeks of rearing. Similarly, Mohapatra and Patra (2014) [17] reported the survivability of common carp in the range of 75%-90%. In a study conducted by Szlaminska *et al*. (1990) [27] on the rearing of common carp by using yeast and beef liver, the survival rate recorded was in the range of 76-96%. Similarly in the present study survival rates varied between 68-82%, with highest from treatment 3 (30% guar inclusion).

Mazurkiewicz *et al*. (2017) [16] an got average SGR of 1.59 to 1.98 whereas, Másílko *et al*. (2014) [15] reported the SGR of common carp larvae in the range of 0.63-0.72. Markovic *et al*. (2012) [14] during 90 days of common carp larvae rearing observed the highest SGR of 1.09% whereas Przybył *et al*. (2006) [21] observed the highest SGR of 3.34% in common carp larvae. Kucharczyk (2013) [13] reported the highest SGR in common carp larvae ranging from 5.99 to 8.69. SGR of carp larvae recorded by Sultana *et al*. (2001) [26] was in the range of 2.52-3.52, based on the different feeding frequencies. While studying the effect of seaweeds on the growth performance of common carp larvae, SGR recorded by Zaki *et al*. (1994) [28] was in the range of 0.90-1.22%. Similarly in the present study, SGR was recorded in the range 2.5-3.5%, with the highest from treatment 3 (30% guar replacement).

FCR reported from larvae under different treatments varies from 0.6-1.5. One of the reasons for this FCR value may be the presence of phytoplankton in the culture tanks that were added during the initial phase of the work. Mohapatra and Patra (2014) [17] indicated the presence of live food particles for better and fast growth of early juveniles of common carp. Moreover, studies have revealed that larvae have a fast growth rate as compared to other life stages which may be another reason for this FCR value. The feed conversion ratio decreased progressively with a linear increase in dietary protein level and was found to differ significantly among each dietary protein level (Ahmed and Maqbool, 2016) [30]. Mazurkiewicz *et al*. (2017) [16] reported the FCR of common carp in the range of 1.05 to 1.19. Similarly, Masilko *et al*. (2014) [15] reported the FCR of common carp in the range of 2.04-2.5. While finding the effect of feeding frequency on growth of common carp larvae, Sultana *et al*. (2001) recorded the FCR of 1.22 for feeding four times a day and FCR value of 1.78 was obtained by feeding twice a day. FCR observed by Markovic *et al*. (2012) [14] during 90 days of carp rearing was in the range of 1.49 to 2.82, whereas Przybył *et al*. (2006) [21] got the FCR between 1.29 and 2.66. Kucharczyk *et al*. (2013) [13] reported the FCR for common carp rearing in the range of 1.06-2.59. Zaki *et al*. (1994) [28] also got the same results while feeding common carp with seaweeds.

Kucharczyk (2013) [13] reported the highest average individual growth rate by offering feed @12% body weight. Mohapatra and Patra (2014) [17] reported a maximum daily weight gain of 0.056g day-1 of common carp (fed with fish meal + soybean + Groundnut cake +rice bran + wheat flour). Zaki *et al*. (1994) [28] recorded an average ADG of 13.27-21-63% by feeding common carp with seaweeds. Thus, the results of the present study are comparable with above-mentioned studies.

5. Conclusion

From the present study, it is clearly evident that all the growth parameters recorded maximum values in treatment 3 (30% guar inclusion) and the lowest was from the control. All the growth parameters recorded show an increasing trend up to 30% replacement, which indicates that effective replacement of soy meal by guar meal up to 30% does not have any significant effect on growth and survival of common carp larvae. Thus, we recommend that soy meal can be effectively replaced by guar meal upto the level of 30%.

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7. Ethical statement

The experiment was conducted following the procedures of CPCSEA (Committee for the Purpose of Control and Supervision of Experiments on Animals), Ministry of Environment and Forests (Animal Welfare Division), Government of India on the care and use of animals in scientific research.

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